Gof Design Patterns

STRUCTURAL PATTERNS

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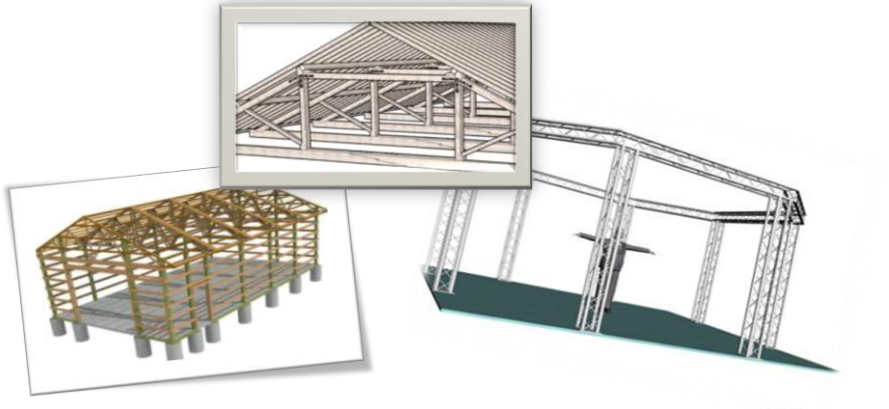

Structural Patterns

Concerned with the structural relationships between classes and objects

Facade

Façade Meaning

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- fa·cade –
- The face of a building, especially the principal face.
- An artificial or deceptive front: *ideological slogans that were a façade for geopolitical power struggles.*

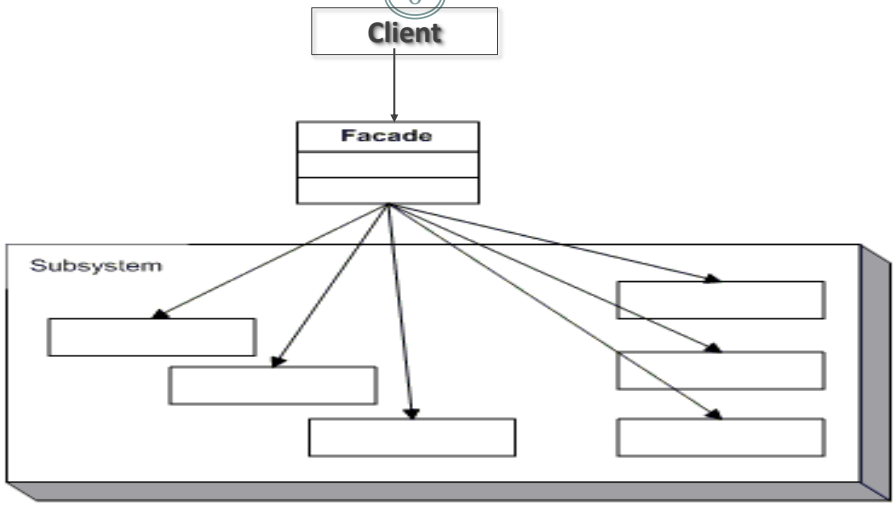
Façade Pattern

Make a complex system simpler by providing a unified or general interface, which is a higher layer to these subsystems

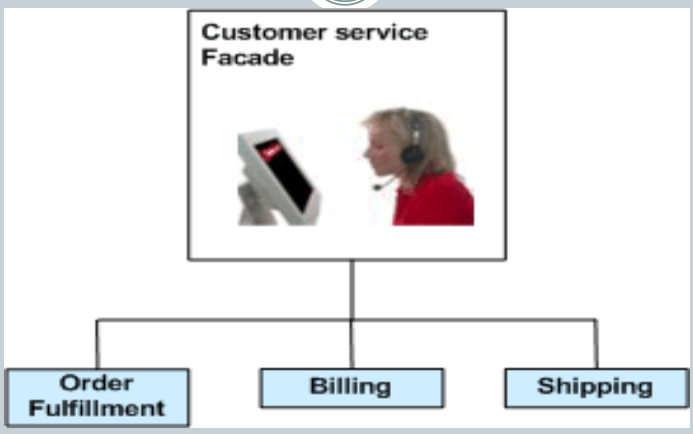
Benefits of Facade Pattern

- Want to reduce complexities of a system.
- Decouple subsystems , reduce its dependency, and improve portability.
- Make an entry point to your subsystems.
- Minimize the communication and dependency between subsystems.
- Security and performance consideration.
- Shield clients from subsystem components.
- Simplify generosity to specification.

Structure



Example



Illustrated Code

```
public class OrderCompletionFacade {
    /**
     * facade method takes in Order details and does the following 1. Process
     * the order completion by calling the order module 2. Updates shipping
     * information 3. Bills the order and Updates billing information
     */
    public void completeOrder(String orderId, String paymentId) {
        new OrderProcessing().completeOrder(); // might fetch and pass Order object to this method

        new BillingImpl().processBilling(); // might pass billing object to this method

        new Shipping().initiateShippingForOrder(); // might create a new shipping object and pass
    }
```

```
class BillingImpl {
    public void processBilling() {
        // contains logic for processing the billing given the credit card
        // details
    }
}
```

```
class OrderProcessing {
    public void completeOrder() {
        // Updates the order records and completes the order
```

```
class Shipping {
    public void initiateShippingForOrder() {
        // initiates the shipping request
    }
    public void captureShippingDetails() {
        // captures the address and does basic verification for zip code etc.
    }
}
```

Façade

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- Mandatory v/s Optional Façade
- Web Services and service-oriented architecture provide a Façade for an entire system

Façade Pattern

Adapter

Adapter

- Convert the interface of a class into another interface clients expect. Adapter lets classes work together that couldn't otherwise because of incompatible interfaces. (Also known as Wrapper)

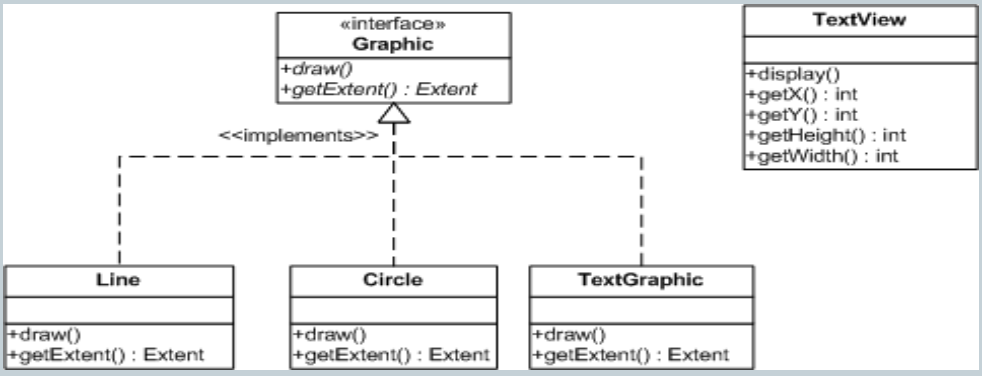
Benefits of Adapter Pattern

- Make unrelated classes work together.
- Multiple compatibility.
- Increase transparency of classes
- Make a pluggable kit.
- Increases class reusability
- Achieve the goal by inheritance or by composition

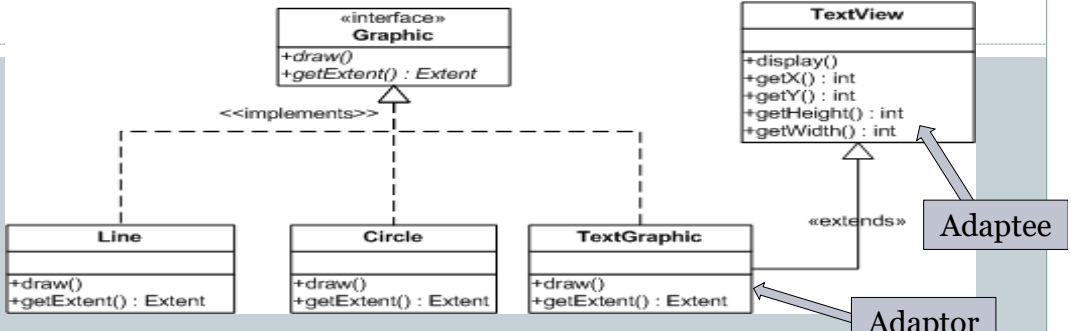
Adapter Pattern

- Class Adapter (Inheritance)
- Object Adapter (Composition)

Example

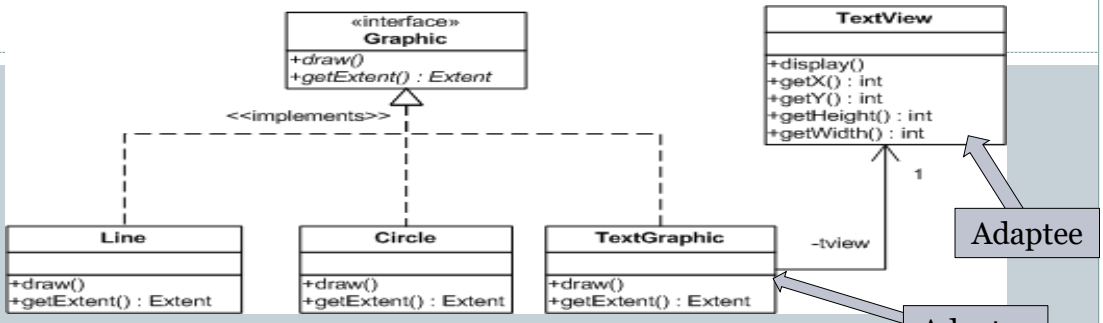


Class Adapter




```
public class TextGraphic extends TextView implements Graphic
{
   public void draw()
   {
        display();
   }
   public Extent getExtent()
   {
        return new Extent(getX(),getY(),getHeight(),getWidth();
        . . . .
   }
}
```

Object Adapter




```
public class TextGraphic implements Graphic
{
   private TextView tView;
   public void draw()
   {
        tview.display();
   }
   public Extent getExtent()
   {
        return new Extent(tView.getX(), tView.getY(), tView.getHeight(),
                  tView.getWidth();
        . . . .
   }
}
```

Adapter Pattern

Adapter

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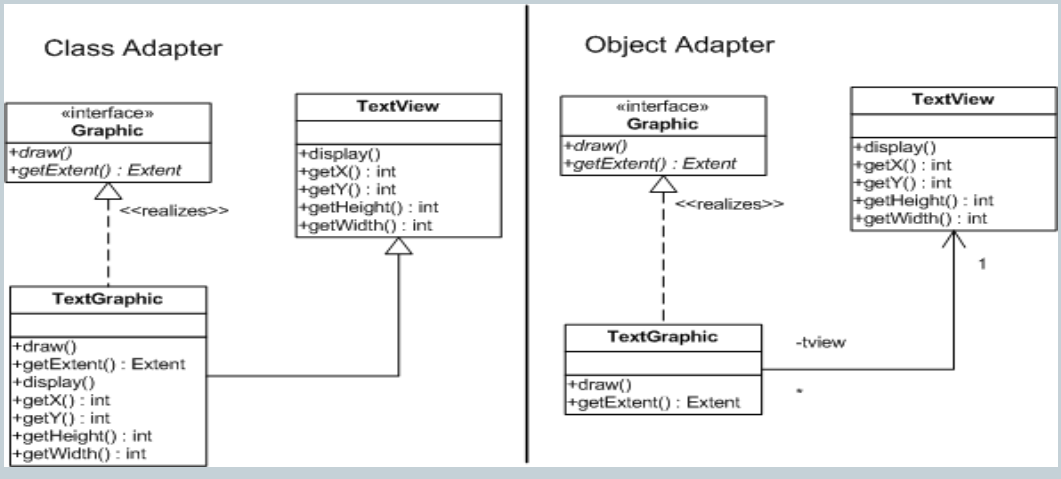
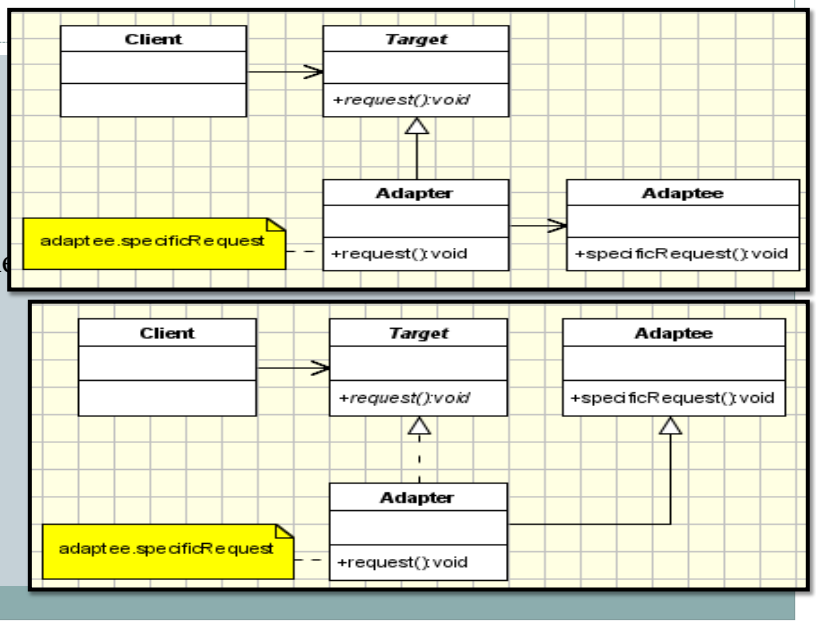


Adapter Pattern

Structure

Target - defines the domain-specific interface that Client uses.
Adapter - adapts the interface Adaptee to the Target interface.
Adaptee - defines an existing interface that needs adapting.
Client - collaborates with objects conforming to the Target interface.



Adapter Classes in Java & C#

- Java
  - javax.print.event.PrintJobAdapter
  - Event adapters :
    - java.awt.event.ComponentAdapter,
    - java.awt.event.MouseAdapter,
    - java.awt.event.ContainerAdapter,
    - java.awt.event.KeyAdapter ,
    - java.awt.event.MouseInputAdapter
  - org.xml.sax.helpers.XMLReaderAdapter (Adapt a SAX2 XMLReader as a SAX1 Parser.)
  - org.xml.sax.helpers.ParserAdapter (This class wraps a SAX1 Parser and makes it act as a SAX2 XMLReader, with feature, property, and Namespace support.)
- C#
  - System.Data.Common.DataAdapter class used with various data sources such as OleDB, Sql, and Oracle
  - Reader/Writer classes are adapters which convert a byte array interface to string/char interface.

Adapter Pattern

- **Applicability**
  - Use the Adapter pattern when you want to use an existing class, and its interface does not match the one you need
  - You want to create a reusable class that cooperates with unrelated classes with incompatible interfaces
- **Implementation Issues**
  - How much adapting should be done?
    - Simple interface conversion that just changes operation names and order of arguments
    - Totally different set of operations
  - Does the adapter provide two-way transparency?
    - A *two-way adapter supports both the Target and the Adaptee interface. It* allows an adapted object (Adapter) to appear as an Adaptee object or a Target object

Adapter Pattern

Bridge

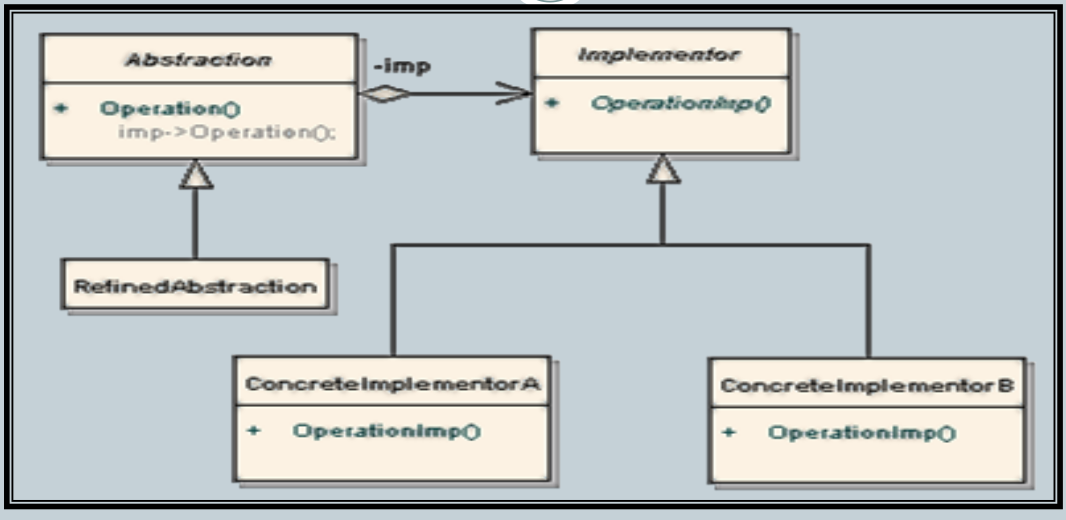
Bridge Pattern

Decouple an abstraction from its implementation so that the two can vary independently.

Usage

- When you want to avoid a permanent binding between an abstraction and its implementation.
- When both the abstraction and implementations should be extensible using subclasses.
- When changes in the implementation of an abstraction should have no impact on clients, which means that you should not have to recompile their code.

Structure



Simple Example

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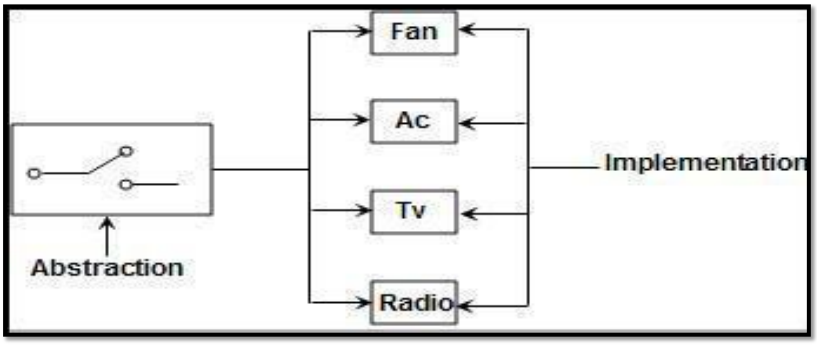


Bridge pattern between interfaces – IEquipment & ISwitch

```
public interface IEquipment
{
    void Start();
    void Stop();
}
```

Inheritance

```
class clsRefrigerator : IEquipment
{
    public  void Start()
    {
        Console.WriteLine("Start Compressor");
        Console.WriteLine("Start Ice Cooling");
    }
    public  void Stop()
    {
        Console.WriteLine("Stop Ice Cooling");
        Console.WriteLine("Stop Compressor");
    }
}
```

```
class clsBulb : IEquipment
{
    public void Start()
    {
        Console.WriteLine("Warm up the bulb");
```

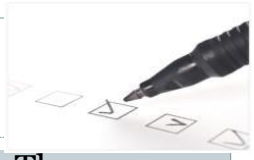
```
interface ISwitch
{
    void On();
    void Off();
}
class Clsswitch : ISwitch
{
    private IEquipment objEquipment;
    public void setEquipMent(IEquipment Equipment)
    {
        objEquipment = Equipment;
    }
    public void On()
    {
        objEquipment.Start();
    }
    public void Off()
    {
        objEquipment.Stop();
    }
```

Abstraction interface

Aggregated Equipment object reference

Implement both the interface

How to use Bridge pattern



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- Decide if two orthogonal dimensions exist in the domain. These independent concepts could be: abstraction/platform, or domain/infrastructure, or front-end/back-end, or interface/implementation.
- Design the separation of concerns: what does the client want, and what do the platforms provide.
- Design a platform-oriented interface that is minimal, necessary, and sufficient. Its goal is to decouple the abstraction from the platform.
- Define a derived class of that interface for each platform.
- Create the abstraction base class that "has a" platform object and delegates the platform-oriented functionality to it.
- Define specializations of the abstraction class if desired.

Bridge Pattern in Java & C#

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- Bridge pattern is used to separate Components and Component Peers.
- Persistence frameworks also use this pattern commonly

Consequences

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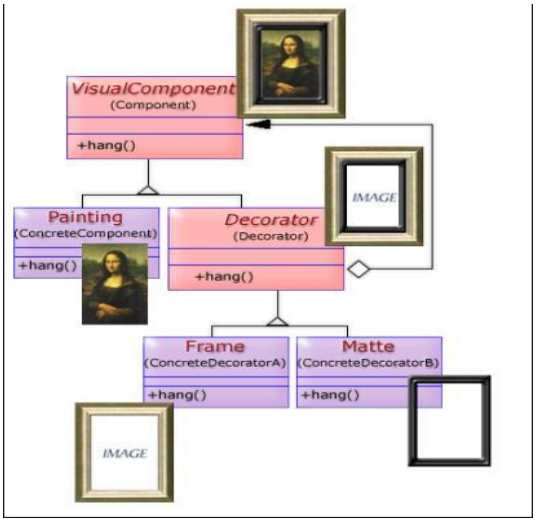
- Decoupling interface and implementation. An implementation is not bound permanently to an interface. The implementation of an abstraction can be configured and even switched at run-time.
- Abstraction and Implementor hierarchies can be extended independently.
- Improved extensibility

Bridge Pattern

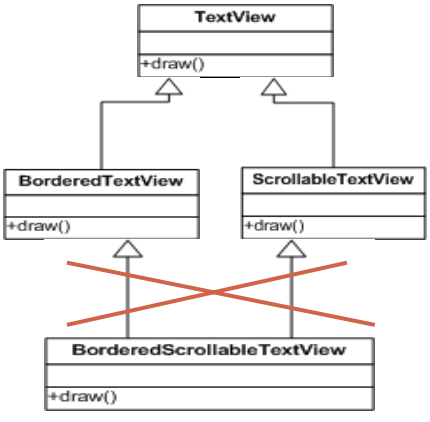


Decorator

Decorator

- Provide additional functionality to a class without subclassing it
- Provide additional responsibilities to an object dynamically

Problem statement



Now consider providing a ruler also for a TextView.

Solution using Decorator Pattern

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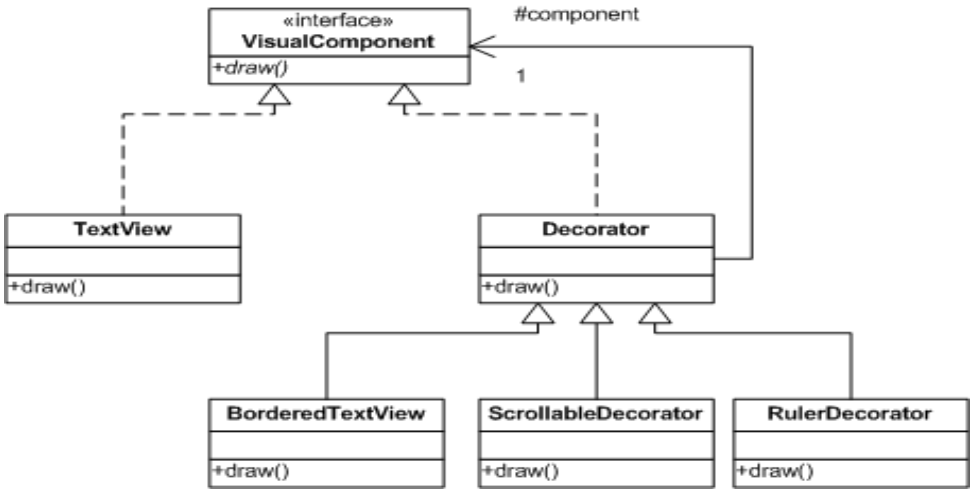


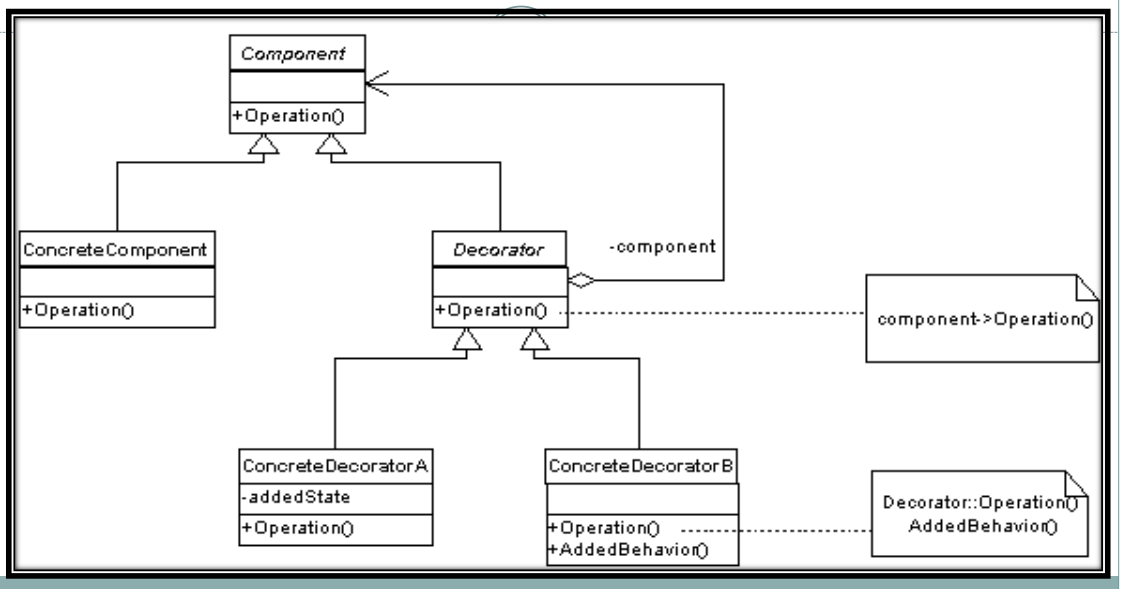
Decorator

```
public abstract class Decorator implements VisualComponent
{    // protected member variable
     protected VisualComponent component;
     // …
}
public class BorderDecorator extends Decorator{
     public BorderDecorator(VisualComponent comp){
          component = comp;
     }
     public void draw() {
          component.draw();
          drawBorder();
     }
     private void drawBorder() {
          //…
     }
}
```

```
public class ScrollbarDecorator extends Decorator{
     public ScrollbarDecorator(VisualComponent
     comp){
          component = comp;
     }
     public void draw() {
          component.draw();
          drawScrollbar();
     }
     private void drawScrollbar() {
```

```
// simple Text View
VisualComponent vc1 = new TextView();
vc1.draw
VisualComponent vc2 = new BorderDecorator(vc1);
vc2.draw
VisualComponent vc3 = new BorderDecorator(new ScrollbarDecorator(vc1));
```

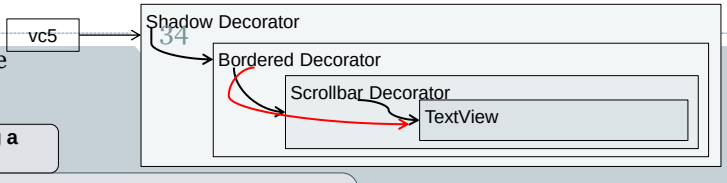
Structure



Decorator Pattern

Decorator Pattern Explained

Many small objects are created



Dynamically removing a Decorator

```
// if client wants to remove scrollbar
vcTemp = vc3;
while(vcTemp instanceof Decorator {
    if(vcTemp  instanceof  ScrollbarDecorator) {
            vcTemp.setComponent =
            vcTemp.getComponent();
            break;
    } else {
            vcTemp = vcTemp.getVisualComponent();
    }
}
```

1 : vcTemp → ShadowDecorator

2 : vcTemp → BorderedDecorator

3 : vcTemp → ScrollbarDecorator
BorderedDecorator.component =
ScrollbarDecorator.component

Decorator in Java & C#

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- In Java
  - All subclasses of java.io.InputStream, OutputStream, Reader and Writer have a constructor taking an instance of same type.
  - Almost all implementations of java.util.List, Set and Map have a constructor taking an instance of same type.
- In C#
  - System.IO.Stream
  - System.IO.BufferedStream
  - System.IO.FileStream
  - System.IO.MemoryStream
  - System.Net.Sockets.NetworkStream
  - System.Security.Cryptography.CryptoStream

Applicability

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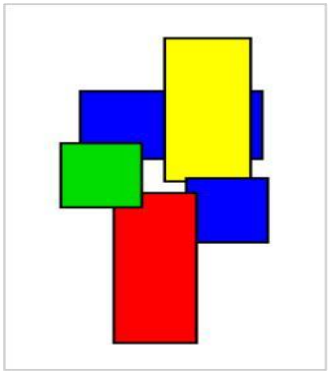
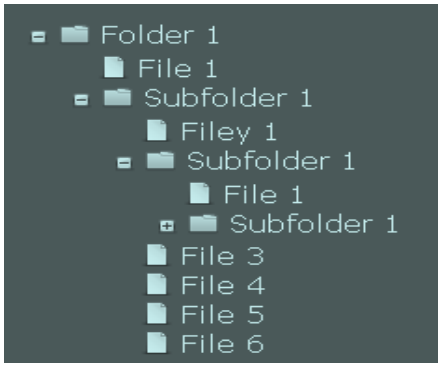
Use the Decorator pattern

- To provide various additional functionalities to an existing class without sub-classing and when the functionalities are more decorative in nature. If a large number of independent extensions and their combinations are possible, subclassing may result in an explosion of classes
- To add responsibilities to individual objects dynamically and transparently, without affecting other objects
- When a class to be extended may not be available for subclassing (final classes in Java)

Consequences

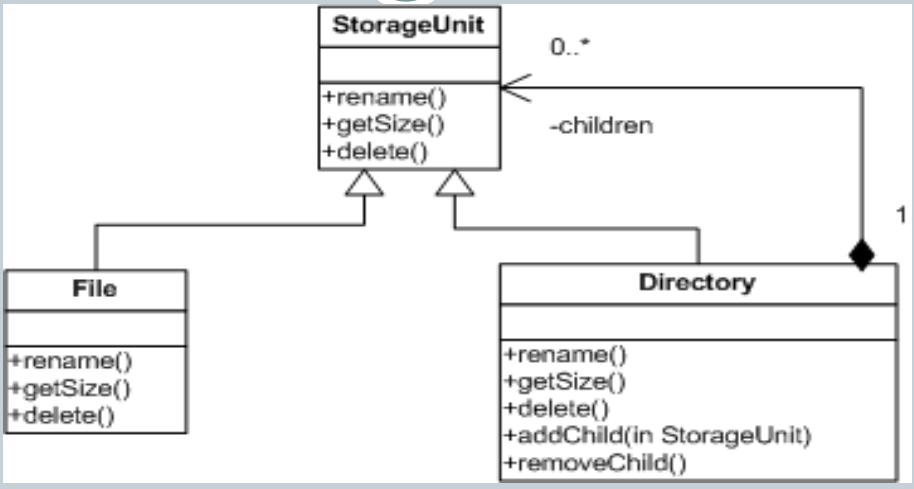
- More flexible than inheritance. Responsibilities can be added / removed dynamically.
- A property can be added multiple times, if required
- Avoids feature-heavy classes high up in the hierarchy. Clients use objects on a pay-as-you-use basis.
- A decorator and its component are not identical
- Results in many small objects





Composite

Windows Explorer example



Windows Explorer example illustrated with code


```
interface StorageUnit {

    public void rename(String name);
    public int getSize();
    public boolean delete();
    public String getName();

}
```

Component

```
class File implements StorageUnit {
    private int size;
    private String name;
    public File(String name, int size){
        this.size = size;
        this.name = name;
    }
    @Override
    public boolean delete() {

        return false;
    }
    @Override
    public int getSize() {
        return size;
    }
    @Override
    public void rename(String name) {
        this.name = name;
    }
    @Override
    public String getName() {
        return this.name;
    }
}
```

Leaf

Code contd..

Composite class

```
class Directory implements StorageUnit {
    //composite of other Storage units
    protected List<StorageUnit> childStorageUnits =
        new ArrayList<StorageUnit>();
    private String folderName;

    public Directory(String folderName)
    {
        this.folderName = folderName;
    }
```

Simple overridden functions

```
    @Override
    public void rename(String folderName) {
        this.folderName = folderName;
    }
    @Override
    public String getName() {
        return folderName;
    }
```

Child management functions

```
    public void add(StorageUnit childStorageUnit) {
        childStorageUnits.add(childStorageUnit);
    }
    public void delete(StorageUnit childStorageUnit) {
        childStorageUnits.remove(childStorageUnit);
    }
```

Composite Pattern

Code contd..

```
class Directory implements StorageUnit {
    //composite of other Storage units
    protected List<StorageUnit> childStorageUnits =
        new ArrayList<StorageUnit>();
```

Composite methods

```
    @Override
    public boolean delete() {
        for (StorageUnit childStorageUnit : childStorageUnits) {
            childStorageUnit.delete();
        }
        deleteFolder(); // delete the folder itself
        return true;
    }
```

```
    @Override
    public int getSize() {
        int foldersize =0;
        for (StorageUnit childStorageUnit : childStorageUnits) {
            int childStorageUnitSize = childStorageUnit.getSize();
            foldersize += childStorageUnitSize;
        }
        System.out.println(this.folderName +" - "+ foldersize);
        return foldersize;
    }
```

Composite Pattern

Composite

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- Used for whole-part structures (aggregation hierarchies)
- To provide polymorphic access to whole objects and part objects
- Group components to form larger components, which in turn can be grouped to form still larger components.
- Compose objects into tree structures to represent whole-part hierarchies. Composite lets clients treat individual objects and compositions of objects uniformly.
- Recursive composition

Composite Pattern

Structure

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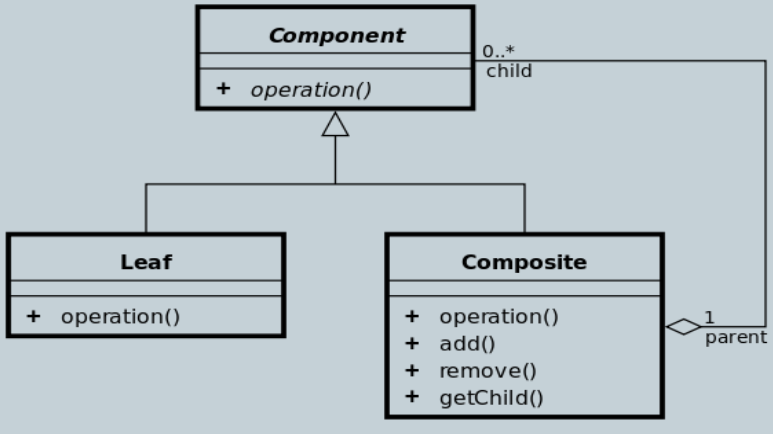

Composite Pattern

Example Java AWT

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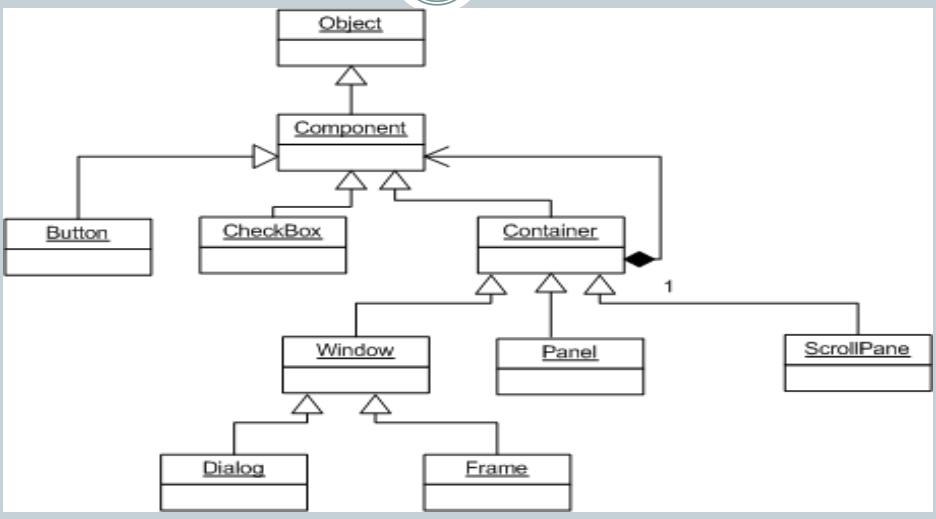

Composite Pattern

Steps to create a Composite Patte

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- Ensure that your problem is about representing "whole-part" hierarchical relationships.
- Consider the heuristic, "Containers that contain containees, each of which could be a container." For example, "Assemblies that contain components, each of which could be an assembly." Divide your domain concepts into container classes, and containee classes.
- Create a "lowest common denominator" interface that makes your containers and containees interchangeable. It should specify the behavior that needs to be exercised uniformly across all containee and container objects.
- All container and containee classes declare an "is a" relationship to the interface.
- All container classes declare a one-to-many "has a" relationship to the interface.
- Container classes leverage polymorphism to delegate to their containee objects.
- Child management methods [e.g. addChild(), removeChild()] should normally be defined in the Composite class.

Flyweight

Flyweight

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- Main purpose of Flyweight is to save space (memory)

Document Editor Problem Statement

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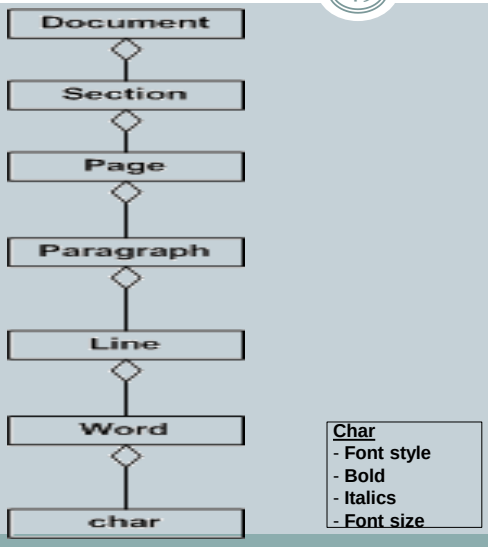

Flyweight Pattern

Using Composite

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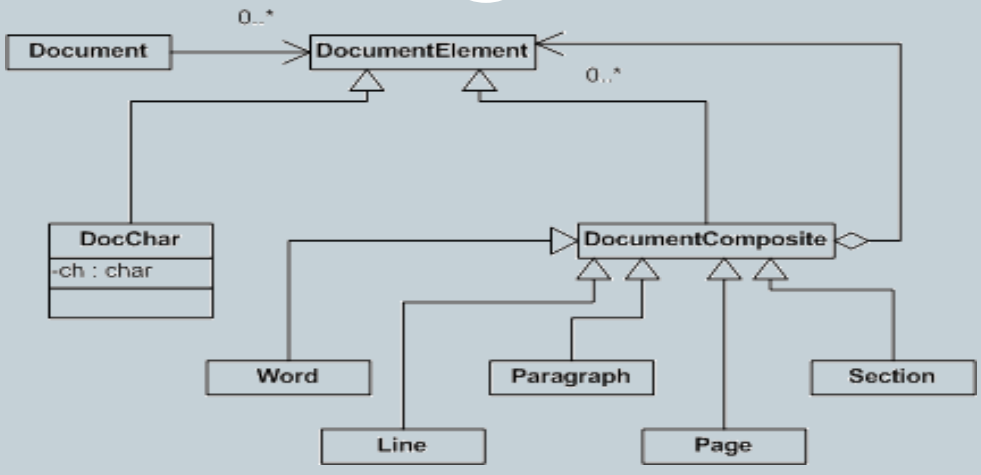

Flyweight Pattern

Issues with Composite approach?

- As a user types in some character in the document, a corresponding DocChar object is created and added to the document data structure.
- As a result large number of DocChar objects will be created in memory.

How much memory would be required ?

Consider 1 document ~ 4 sections ~ 25 pages each ~ Average of 5 paragraphs each ~ Average of 6 sentences in each ~ Average of 8 words in each ~ Average of 4 characters in each word.

We will need different variables to store each of them : (Considering 32 bit system)

1 variable – **document**		1 x 4 bytes	= 4
4 variables – **section**		4 x 4 bytes	= 16
4 x 25 variables – **pages**	100 x 4 bytes	= 400	
100 x 5 variables – **paragraphs**	500 x 4 bytes	= 2000	
500 x 6 variables – **sentences**		3000 x 4 bytes	= 12,000
3000 x 8 variables – **words**		24,000 x 4 bytes	= 96,000
24,000 x 4 variables – **characters**		96,000 x 4 bytes	= 384,000
Total		123,605	494,420

Too much memory

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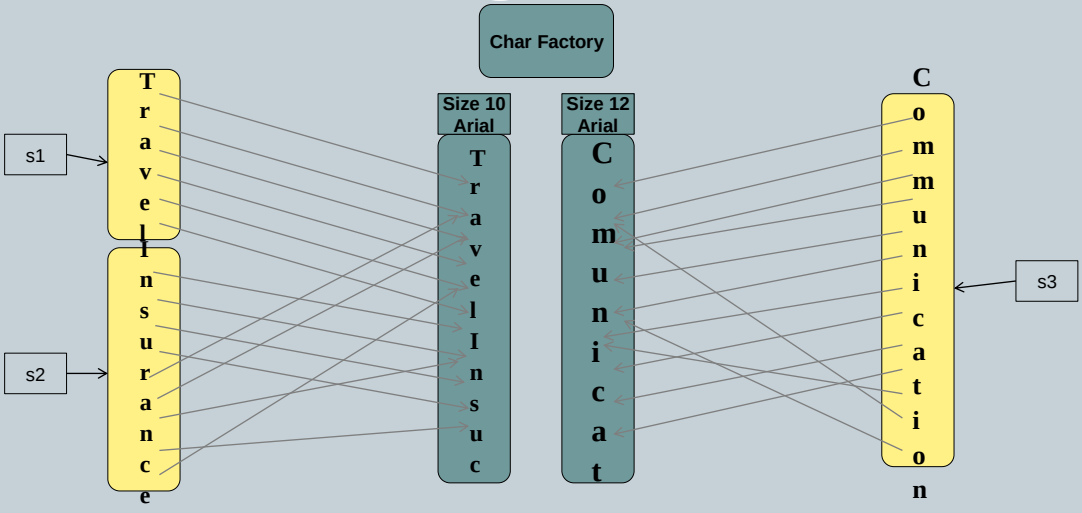
- How can we reduce the memory being utilized?
- Can we reuse something?
  - Lets start from the lowest element character
    - Do we need 96,000 variables for characters?
    - How many characters do I have (26 a-z, 26 A – Z, 0 – 9, special characters etc). In all around 60 usual characters. Considering each of them in different font sizes, styles used in the document might go up to 500 characters.
    - Can we reuse the 500 characters in different words instead of creating 96,000 characters in memory.

How can we reuse?



Flyweight

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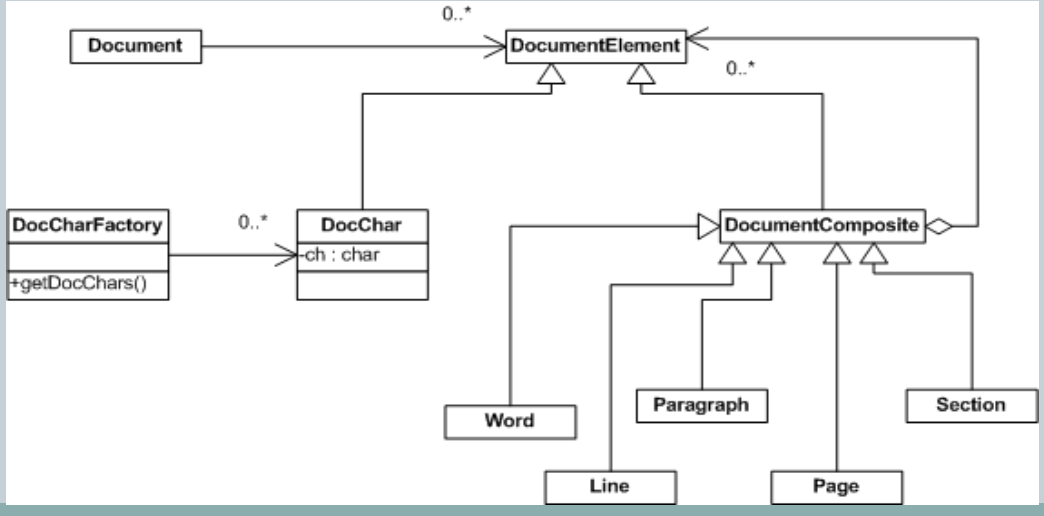

Flyweight Pattern

When to use Flyweight

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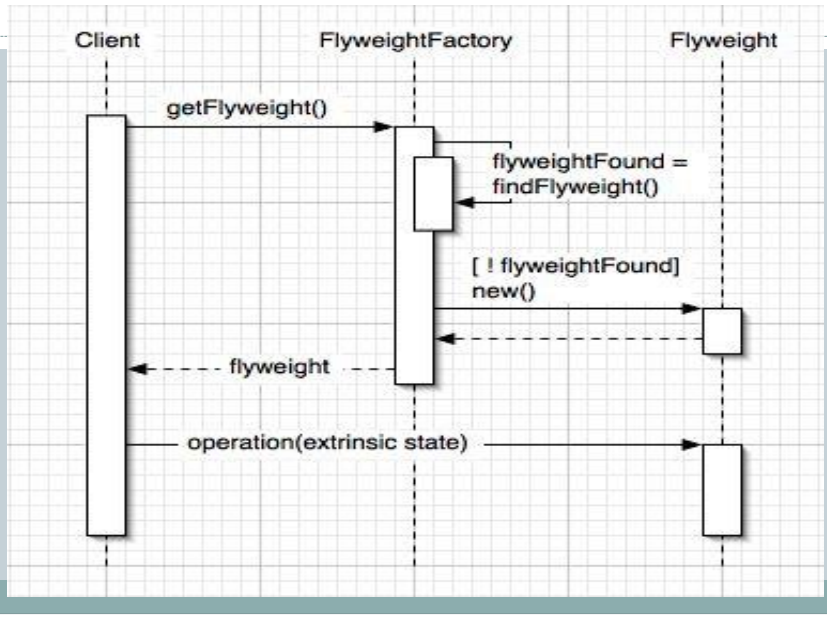
Use the Flyweight pattern when all the following are true :

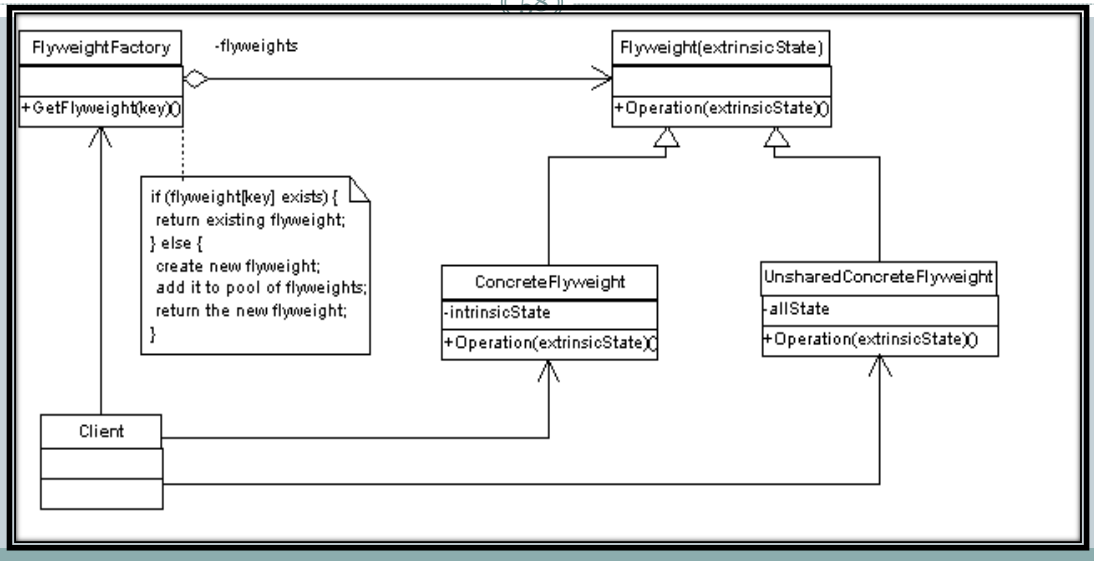
- An application uses a large number of objects
- Storage costs are high because of sheer quantity of objects
- Unique values of some object attributes is a small percentage of the total number of objects
- A large number of objects may, therefore, be replaced by relatively few shared objects
- The application does not depend on object identity. Since flyweight objects may be shared, identity tests will return true

Flyweight Pattern

Sequence Diagram



Structure



Flyweight Pattern

Benefits and Usage

Benefits

- Reduction in the number of objects to handle.
- Reduction in memory and storage devices if the objects are persisted.

Usage

- When the application uses large number of objects.
- Storage costs are high because of the quantity of objects.
- The application doesn't depend on object identity.

Proxy

Proxy

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- Proxy pattern is used to provide a surrogate or placeholder for another object to control access to it.
- One class controls the creation of and access to objects in another class

Proxy example

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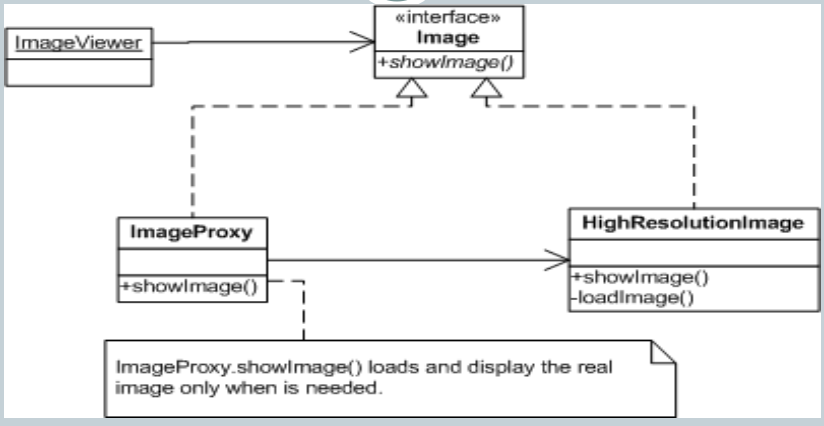

Proxy Examples

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Below are some of the common examples in which the proxy pattern are used:

- Adding security access to an existing object. The proxy will determine if the client can access the object of interest.
- Simplifying the API of complex objects. The proxy can provide a simple API so that the client code does not have to deal with the complexity of the object of interest.
- Coordinating expensive operations on remote resources by asking the remote resources to start the operation as soon as possible before accessing the resources.
- Adding a thread-safe feature to an existing class without changing the existing class's code

Structure

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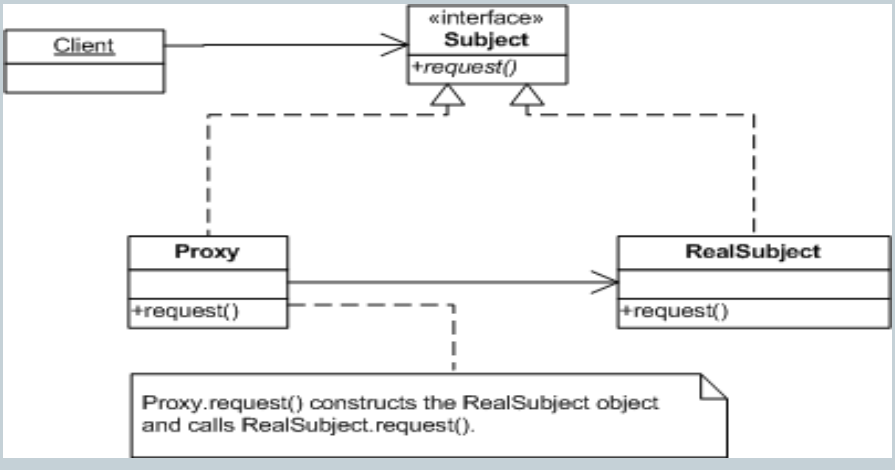
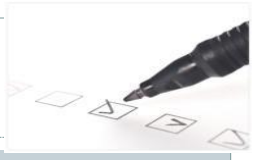


Steps to implement proxy



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- Identify the leverage or "aspect" that is best implemented as a wrapper or surrogate.
- Define an interface that will make the proxy and the original component interchangeable.
- Consider defining a Factory that can encapsulate the decision of whether a proxy or original object is desirable.
- The wrapper class holds a pointer to the real class and implements the interface.
- The pointer may be initialized at construction, or on first use.
- Each wrapper method contributes its leverage, and delegates to the wrappee object.

Proxy Pattern

```
namespace ProxyPatternDemo
{
    public interface IShape
    {
        string GetShape();
    }

    public class RealPolygon : IShape
    {
        public void Details()
        {
            Console.WriteLine("This is real polygon Class");
        }
        public string GetShape()
        {
            return "This is polygon shape from real/ actual class";
        }
    }

    public class ProxyPolygon : IShape
    {
        IShape _shape;
        public void Details()
        {
            Console.WriteLine("This is Proxy polygon Class");
        }
        public string GetShape()
        {
            _shape = new RealPolygon();
            return _shape.GetShape();
        }
    }
```

```
    class Program
    {
        static void Main(string[] args)
        {
            ProxyPolygon proxyClass = new ProxyPolygon();
            proxyClass.Details();
            string RealPolygonDetails = proxyClass.GetShape();
            Console.WriteLine(RealPolygonDetails);
            Console.ReadLine();
        }
    }
}
```

```
This is Proxy polygon Class
This is polygon shape from real/ actual class
```

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Proxy implementations in Java

- java.lang.reflect.Proxy
- java.rmi.* (Remote Proxy)

Types of Proxies

There are four types of proxies, all taking the same basic format:

1. Virtual Proxy - The proxy won't create an "expensive" subject object until it is actually needed.
2. Remote Proxy - A local proxy object controls access to a remote subject object.
3. Protection proxy - The proxy insures that the object creating/calling the subject has authorization to do so.
4. Smart reference - The proxy will perform "additional actions" when the subject is called.

Benefits & Usage

Benefits

- A remote proxy can hide the fact that an object resides in a different address space.
- A virtual proxy can perform optimizations such as creating an object on demand.
- both protection proxies and smart references allow additional housekeeping tasks when an object is accessed.

Usage

- when you need a more versatile or sophisticated reference to an object than a simple pointer.

End of Chapter (Structural Patterns)